ALNOR®

INSTRUMENT COMPANY

Electronic Services - Los Angeles
M11347X

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GENERAL ELECTRIC
INSTRUMENTATION & COMMUNICATION
1200 KONA DRIVE
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OPERATING AND SERVICE MANUAL

DIGICON®

SERVICE MANUAL

model 6670

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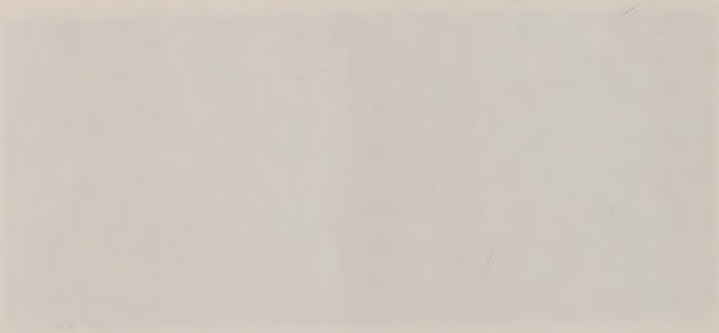

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1.0 Introduction

1.1 Purpose of this manual

This manual provides an Alnor-designated Digicon ® service center with the information needed to calibrate and repair the 6670 Digicon ® portable pyrometer. The information includes personnel and laboratory requirements, theoretical background for calibration and troubleshooting, and specific calibration and troubleshooting procedures.

1.2 Reference: Digicon ® Owner's Manual, #116-337-007, dated September, 1976

1.3 Qualifications for servicing the instrument

The service technician working on the Digicon ® should have a technical trade school background and at least one year of experience testing and servicing analog and digital electronic instruments.

1.4 Laboratory requirements

Servicing the instrument requires the following tools, test equipment, and materials.

1.4.1 a Phillips screwdriver with a 0 point size

1.4.2 a blade screwdriver with a 3/32 in (.238 cm) blade width

1.4.3 a soldering iron of the controlled-temperature type (600°F) with a 1/32 in (.079 cm) conical tip (Weller type W-TP or equivalent)

1.4.4 a Solderpult ® (EDSYN model DS 017)

1.4.5 a pair of long-nose pliers, 4.75 in (121 cm) recommended

1.4.6 a pair of wirecutters

1.4.7 two 24-gauge copper wires, each from 24 in (69 cm) to 48 in (122 cm) long

1.4.8 four pairs of 24-gauge extension lead-wires -- one pair for H-alloy thermocouples, one for E-alloy TCs, one for J-alloy TCs, and one for K-alloy TCs; each H-alloy must be 46.5 in $\pm$ 2 (118 cm $\pm$5) long; all others can be anywhere from 24 in (69 cm) to 48 in (122 cm) long

1.4.9 a TC plug (Alnor part number 1381)

1.4.10 a trigger-mode, dual-trace oscilloscope with a 10-megahertz bandwidth (Tektronix 922 or equivalent)

1.4.11 two X 10 probes

1.4.12 a frequency counter (Hewlett Packard 5300A or equivalent)

1.4.13 a 15-volt power supply (Lambda model LPD-421A-FM recommended)

1.4.14 a millivolt source (DAS-46A by General Resistance)

1.4.15 a 32°F (0°C) ice point reference (Omega model TRC or equivalent)

1.4.16 solder (resin-core only) as required

1.4.17 denatured alcohol or commercial defluxing solvent as required

1.4.18 a small bottle of nail polish, with applicator

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2.0 Temperature-measurement theory

2.1 Thermocouples

A thermocouple (TC) is a transducer consisting of two dissimilar metal (alloy) junctions. This junction system generates a non-linear, millivolt (mV) level signal proportional to temperature. With the cold junction (or cold end) at a reference temperature of 32°F (0°C) the temperature of the TC junction can be determined from the mV output. A basic temperature-measuring system is shown below.

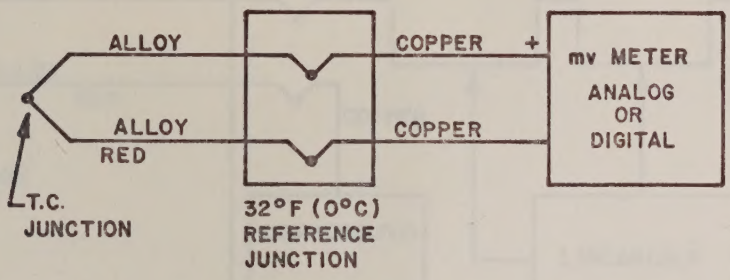


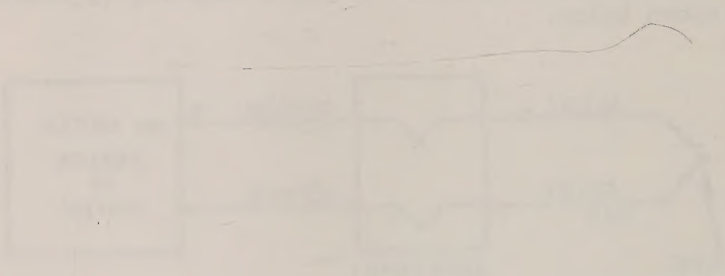
Figure 1.
Basic Temperature-measuring System Using TC

2.1.1 The common TC alloys are K (chromel-alumel), J (iron-constantan), and E (chromel-constantan). H alloy is an Alnor special. The temperature-equivalent millivolt outputs are:

Alloy	µV/°F	µV/°C
K	22	39.6
J	28	50.4
E	34	61.2
H	35	63.0

2.2 Cold-junction compensation

The system in Figure 1 is cumbersome to use from a practical standpoint, since a 32°F (0°C) reference must be maintained. Practical systems make use of temperature sensitive, passive components, such as resistors with special temperature coefficients, as corrective elements. The desired effect of these resistors is adding mV to or subtracting mV from the TC output, with the result proportional to the TC junction temperature. For example, the compensator used with J alloy cancels out the effect of an ambient temperature higher than 75°F, by adding 28 µV/°F to the incoming TC signal. It cancels out the effect of an ambient lower than 75°F by subtracting 28 µV/°F from the incoming signal.



3.0 Digicon® theory of operation

The Digicon® is a temperature-measuring system consisting of a thermocouple, cold-junction compensator, and digital millivolt meter.

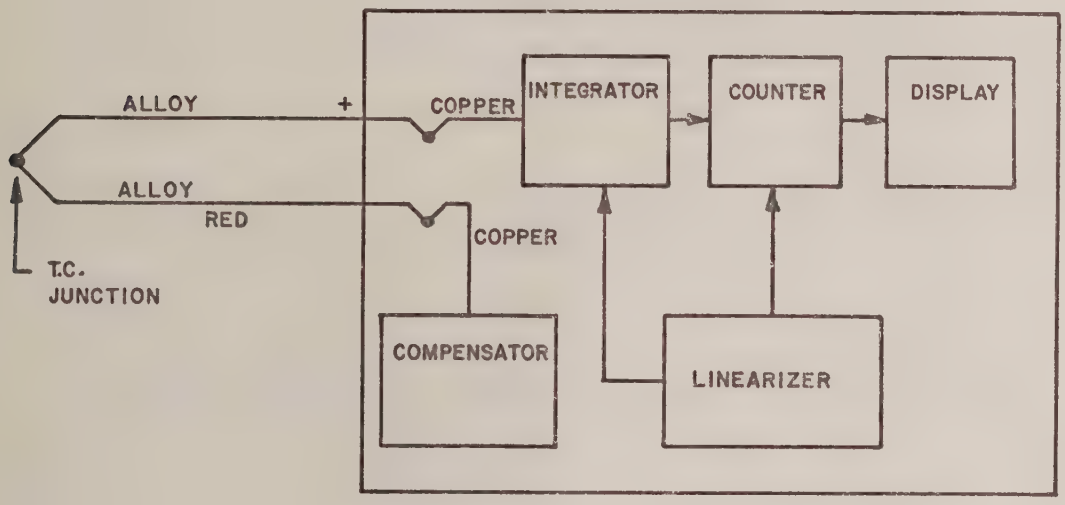


Figure 2.
Digicon® Simplified Block Diagram

3.1 Compensator

The cold-end compensator consists of a bridge circuit with a positive temperature coefficient, the magnitude of which is equal to the μV/° (F or C) of the TC alloy the instrument is calibrated for.

3.2 Integrator

The mV signal is converted to digital form in the integrator. The output of the integrator is a negative pulse (Gated EOC), the width of which is proportional to the mV signal. The Gated EOC pulse can be from 0 to about 31 milliseconds in duration. The period of Gated EOC varies with alloy used, as follows:

Alloy	Typical Period
K	1.3 seconds
J	1.3 seconds
H & E	1.6 seconds

3.3 Linearizer

This clock circuit changes the conversion gain (μV/°, F or C) to make 1° of temperature measured by the TC anywhere within its range equal to 1° on the display. The frequency of the clock decreases at two points in the TC range: 256°F (124°C) and 512°F (267°C). Up to 256°F, the clock runs at its highest frequency. From 257°F (125°C) to 512°F, it runs at a reduced frequency. From 513°F (267°C) up, the clock runs at its lowest frequency. The high and low frequency limits are determined by the TC alloy being used.

3.4 Counter

The width of Gated EOC is timed by the linearizer--one pulse equals one degree (F or C). Decade counters then total the number of clock pulses.

3.5 Display

The display gives visual indication of the number of clock pulses totaled in the counters; that is, it displays the temperature at the desired scale.

4.0 Functional circuit descriptions

4.1 Compensator

The compensator is a bridge circuit composed of R1, R4, R5, R10, R25 S1B, and B3. R5 is a high-temperature-coefficient resistor (3055ppm/°F, or 5500ppm/°C). The current through R5 that determines the μ/° (F or C) to be added or subtracted from the TC output, is set by R4. R10 (COMP) is the balance adjustment for the bridge. B3 is a mercury cell used for bridge excitation through S1B.

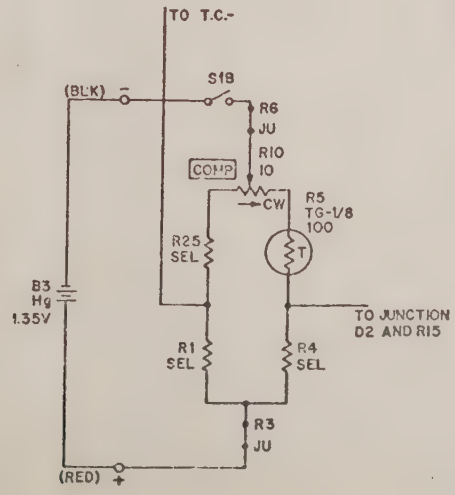


Figure 3.
Compensator Circuit

4.2 Integrator

4.2.1 Principal elements of the integrator

4.2.1.1 A +4.4-volt reference made up of D2, R15, C5 with voltage divider R18, R19.

4.2.1.2 A current source, IC3, composed of matched PNP transistors IC3 connected as a current mirror. R20, R22 (SPAN adjustment) and D2 set the current output of IC3.

4.2.1.3 IC5 is a comparator with one input (pin 3) connected to the +4.4-volt reference. Ouptut of IC5 will switch to a positive level when input at pin 2 slightly exceeds +4.4-volt. C6 and C7 are bypass capacitors. R13 is a pullup for IC5 output (EOC).

4.2.1.4 Inverter Q3 is made up of R14, R16 and Q3. EOC is inverted at this point.

4.2.1.5 Analog switch Q4 is made up of R24, D3, D4 and Q4. D3, D4, and R24 form an "AND" gate that turns Q4 on when Φ1 and EOC are both high.

4.2.1.6 Quad switch IC1 performs the function of four independent SPST switches. High level at "control" input C will make contacts.

4.2.1.7 Dual-input "NAND" gate IC9 generated the Gated EOC pulse.

4.2.2 Sequence of integrator operation

4.2.2.1 With Φ2 positive and Φ1 negative, R7, R8, R9, R11, C1, C2, C3, C4, Q1, and IC2 form the current sink to discharge C9. At this time Q4 and quad switch B are off. Collector Q1 is connected through quad switch A to C9. EOC is high during this time.

4.2.2.2 After 4096 linearizer pulses, Φ1 and Φ2 will reverse state. Quad switch A will turn off, disconnecting Q1 from C9. EOC will have a negative transition when voltage across C9 equals +4.4 V. At this time, Q4 will turn on, holding C9 at +4.4-volts until next cycle begins.

4.2.3 Rate of Gated EOC pulse formation

For every sixteen Φ1-Φ2 cycles, a display update will be generated causing one Gated EOC pulse to form.

4.2.4 Low battery alarm function

Another function of the integrator is to alarm on low battery. IC4 is an op-amp comparator that switches when the voltage sampled from battery through R17, R21 and R23 (Low Battery) becomes less than +4.4 V. Q2 drives the low battery LED lamp. R12 limits the output current of Q2. R23 sets the voltage for the low battery alarm.

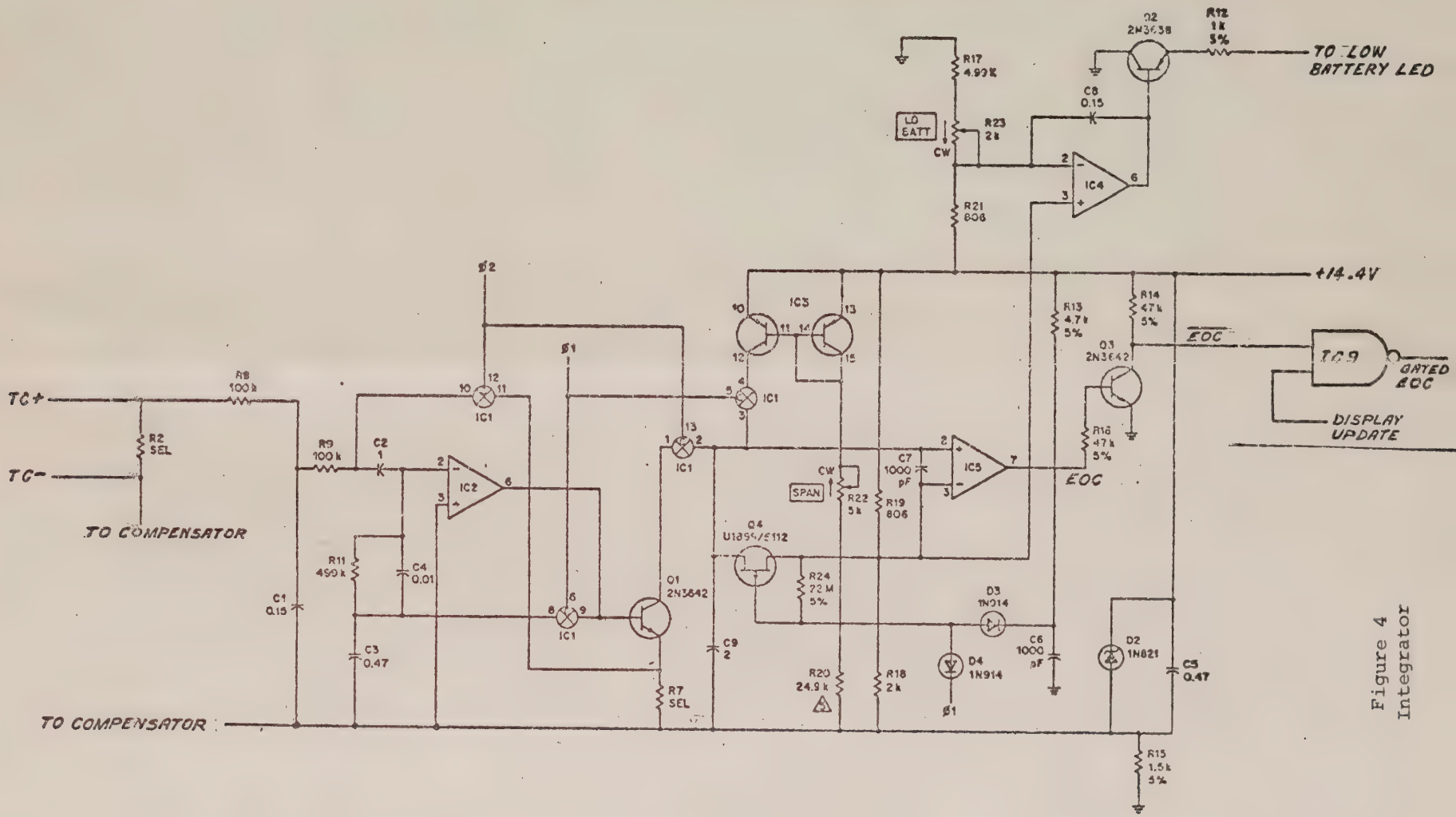


Figure 4
Integrator

4.3 Counter

IC5 comprises the counter section. It consists of a 4-digit decade counter, a latch and a 7-segment decoder.

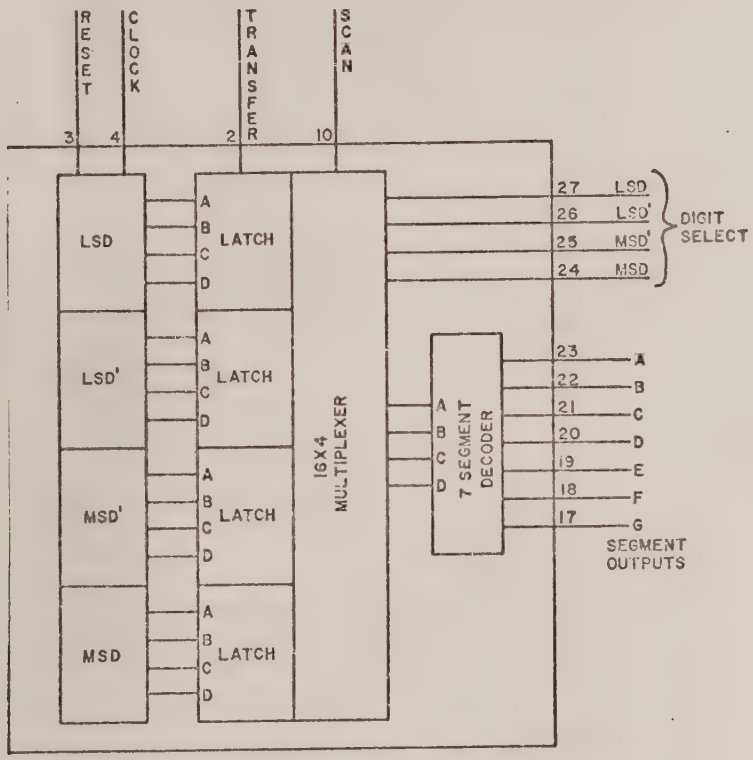


Figure 5. Counter Circuit (IC5 digital PC assembly)

4.3.1 Sequence of counter operation

4.3.1.1 While the Gated EOC high, a number (four digits) is held in the BCD latch. A 7-segment code for the latch content is present at pins 17 through 23, one digit at a time. The codes are continually sequenced (scanned) from the most significant digit (MSD) to the least significant digit (LSD). One digit is scanned for each pulse on pin 10.

4.3.1.2 When the Gated EOC switches low, the counters are reset by a negative pulse (25 µsec) on pin 3. The latch outputs (and 7-segment outputs, as well) track the output of the decade counters. Decade counters register one count for every linearizer pulse on pin 4.

4.3.1.3 At one linearizer pulse before positive transistion of Gated EOC, the latches store the decade-counter output.

4.4 Linearizer

The principal elements of the linearizer are: an RC oscillator consisting of three inverters (IC9); and R3, R9, R1,(B SEG), R2, (T SEG), R8 and C1. R1 and R2 switch in and out of the circuit to change oscillator frequency.

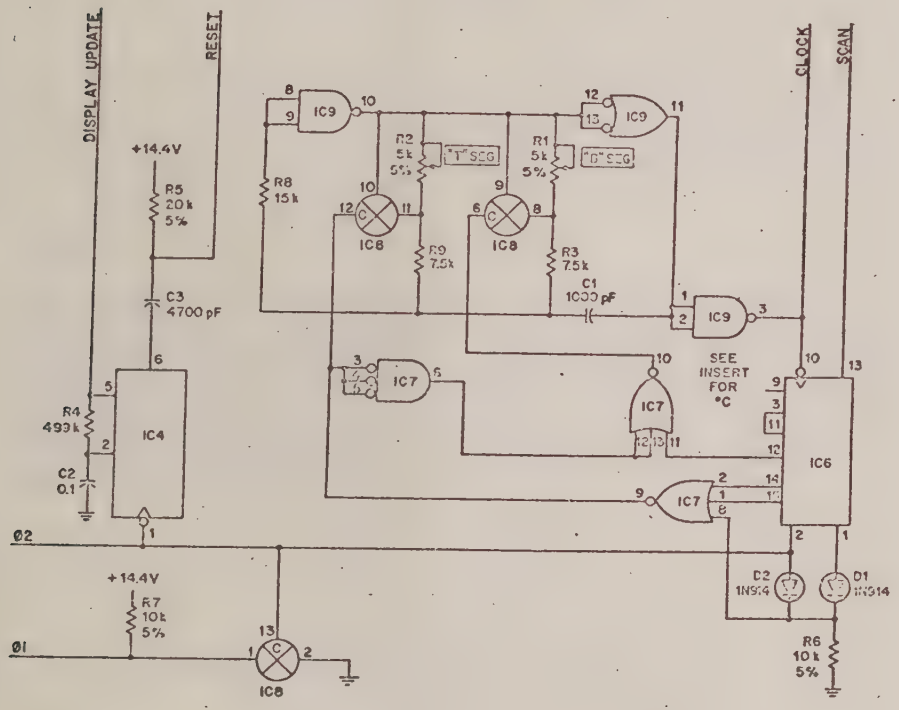


Figure 6.

Linearizer Circuit

4.4.1 Sequence of linearizer operation

4.4.1.1 At the beginning of Φ1, counter IC6 (14-stage binary) is set to 0. Outputs of IC7 are high--therefore two sections of quad switch IC8 (C and D) are shorting out R1 and R2, causing the clock to run at maximum frequency.

4.4.1.2 At clock pulse 256 (as counted by IC6), quad switch C opens, causing R1 and R3 to form a series combination. This causes the clock frequency to decrease, depending on setting of R1 (B SEG).

4.4.1.3 At clock pulse 512, quad switch D also opens, causing R2 and R9 to form a series combination. This causes further decrease of clock frequency, depending on setting of R2 (T SEG). Until the next Φ1/Φ2 cycle, clock frequency remains constant.

4.4.1.4 3584 counts later, Φ1 will switch low and Φ2 will switch positive. 4096 counts later, the cycle will repeat.

4.4.2 Other linearizer functions

4.4.2.1 Generation of Φ2 (÷ 8192 output of IC6)

4.4.2.2 Φ2 is inverted by quad switch A. Output is called Φ1.

4.4.2.3 390 Hz signal is tapped from binary IC6, to drive scanner in IC5 for display multiplex.

4.4.2.4 Φ2 drives binary IC4. From IC4 are derived reset pulse for IC5 (÷ by 8 output of IC4) and a 1.3-second display update pulse. The latter is based on 100 KHz average clock frequency ÷ by 16 output of IC4. The pulse width of 31 mS is determined by value of R4 and C2.

4.5 Display

The 4-digit, 7-segment LED display (output IC5) and LED lamp for the low battery alarm output of integrator are located on the display PC assembly. IC2 is a resistor array to limit display segment current. IC1 is a transistor array (common collector NPN) used to buffer the segment outputs of IC5. IC3 is a transistor array (common emitter NPN) used as buffer for the digit select outputs of IC5.

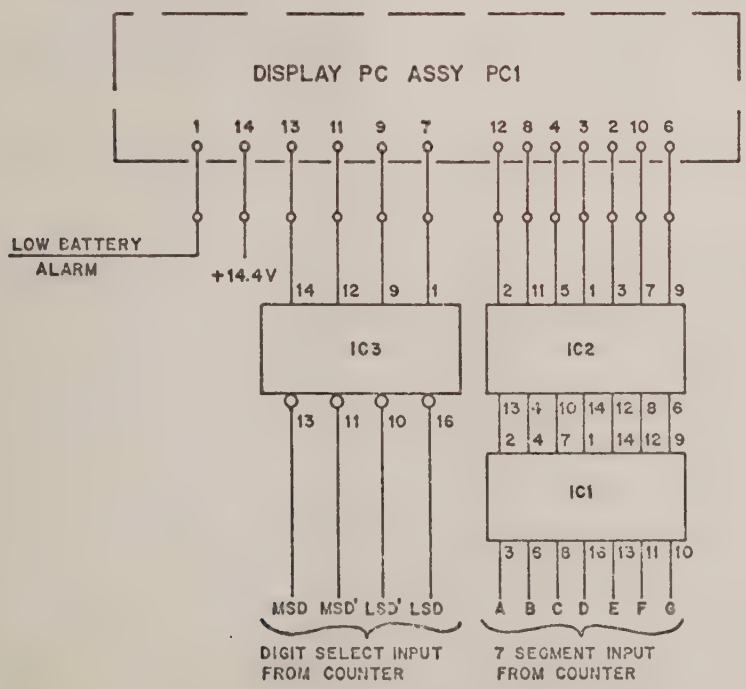

DISPLAY PC ASSY PC1
1 14 13 11 9 7 12 8 4 3 2 10 6
LOW BATTERY ALARM
+14.4V
14 12 9 1
2 11 5 1 3 7 9
IC3
IC2
13 11 10 16
13 4 10 14 12 8 6
2 4 7 1 14 12 9
IC1
3 5 8 15 13 11 10
MSD MSD LSD LSD
A B C D E F G
DIGIT SELECT INPUT FROM COUNTER
7 SEGMENT INPUT FROM COUNTER

Figure 7.
Display Circuit

5.0 Calibration

5.1 After corrective maintenance, checking calibration is a good practice. If the instrument doesn't calibrate properly, or registers incorrect readings, a malfunction is indicated.

5.2 Calibration adjustments

There are four adjustments: COMP, SPAN, B SEG, and T SEG.

5.3 Preparing to calibrate

Before calibrating, perform the following steps.

5.3.1 Twist and solder a stripped pair of extension lead-wires of the appropriate alloy to TC plug #1381 -- red wire to pin 1 (negative). Be certain if you are using H-alloy wire that each wire is 46.5 inches $\pm$ 2 (118 cm $\pm$ 5) in length.

5.3.2 Solder a copper wire to each of the extension lead-wires -- at the end of the lead opposite the end connected to the TC plug.

5.3.3 Insulate the copper-alloy junctions and immerse them in one of the wells of the 32°F (0°C) reference.

5.3.4 Connect the free end of each copper wire to the millivolt source. Be sure the copper wire going to the negative terminal of the mV source is the same one that is connected to the red alloy wire.

5.3.5 Open instrument case. (See Section 6.3 for mechanical disassembly instructions.)

5.3.6 Disconnect red wire from NiCd battery and connect the 15-volt power supply between +14.4 V and GND.

5.3.7 Insert TC plug into instrument's TC jack.

5.3.8 Remove the appropriate Linearizer Setting vs. Clock Frequency table from the envelope at the rear of this manual. Table 1 enables you to determine pot settings for the B and T SEG adjustments when you are using TC alloys H or E. Table 2 gives the settings for J-alloy TCs. Table 3 gives the settings for K-alloy TCs.

5.3.9 Connect frequency counter to pin 3 of IC9 at GND.

5.4 Steps in the calibration procedure

5.4.1 Energize the test setup. NOTE: operate the 32°F (0°C) reference for one hour before using it for calibration.

5.4.2 Turn the instrument on and allow one minute for it to stabilize.

5.4.3 Set "B" and "T" SEG pots at maximum counterclockwise positions, then note average reading of the frequency counter to nearest .1 KHz.

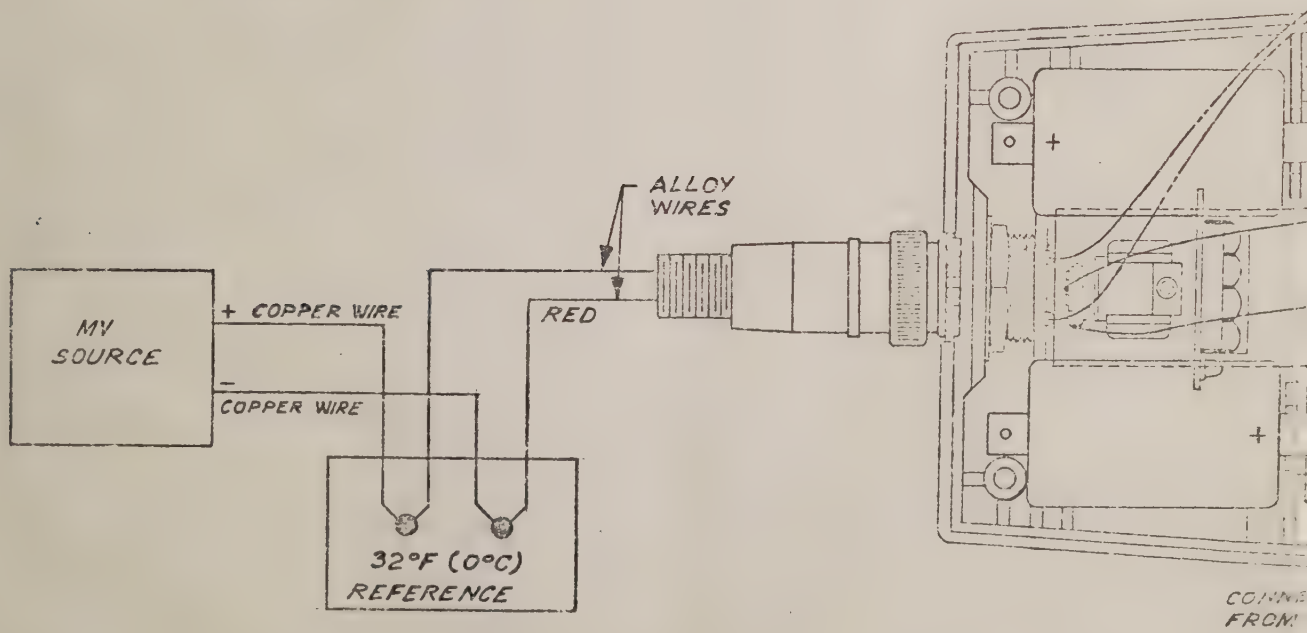
5.4.4 Enter the appropriate Linearizer Setting vs. Clock Frequency table (see Sec. 5.3.8) and find the clock frequency just noted.

5.4.5 Find the "B" SEG pot setting on the same line with and in the column to the right of the clock frequency value. Adjust "B" SEG to that value.

5.4.6 Find the "T" SEG pot setting on the same line with and in the column to the right of the "B" SEG value. Adjust "T" SEG to proper setting.

5.4.7 Set mV source for 0 millivolts.

Figure 8.
Instrument Calibration Setup



5.4.8 Adjust COMP setting to establish a reading of 34°F (1°C).

5.4.9 Set mV source for 41.55 mV if using an H-alloy TC; to 29.52 mV if using a J-alloy TC; to 22.26 mV if using a K-alloy TC; or to 40.05 mV if using an E-alloy TC.

5.4.10 Adjust SPAN setting to establish a reading of 1000°F (538°C)

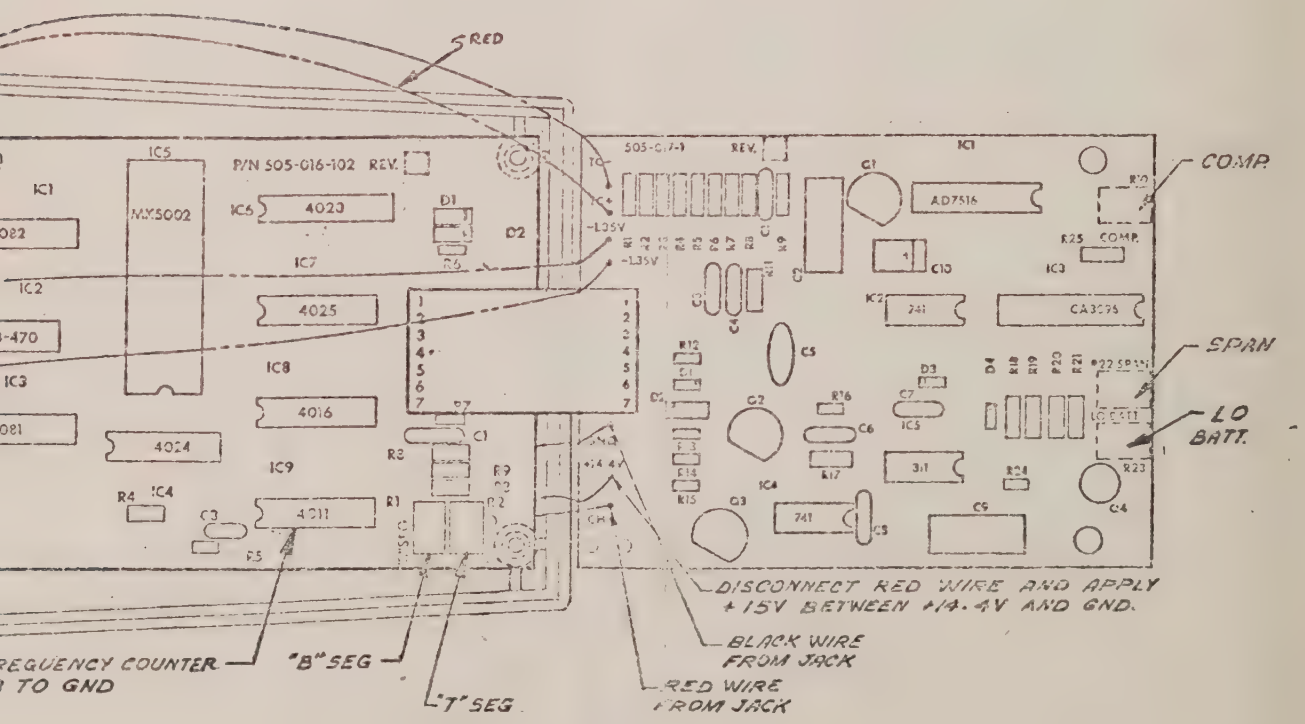
5.4.11 Repeat setps 5.4.9 and 5.4.10.

5.4.12 Check reading at mV input for temperatures of 32°F (0°C), 75°F (24°C), 200°F (93°C), 500°F (260°C), and 1000°F (538°C). De viation should not exceed ± 2° (F or C).

5.4.13 Reduce power supply voltage to + 13.8 V.

5.4.14 Turn LO BATT adjustment clockwise until the low battery LED lights. Then turn LO BATT adjustment counterclockwise and stop at the point when the lamp goes out.

5.4.15 Seal pots by dabbing nail polish over adjustment screws.



6.0 Troubleshooting

6.1 General

This section will enable you to isolate and repair many of the troubles that can cause the instrument to malfunction.

6.2 Special precautions for PC assembly repairs.

6.2.1 Remove PC assemblies from instrument enclosure before attempting to repair them (See Sec. 6.3 for mechanical disassembly instructions).

6.2.2 Remove excess solder completely by the vacuum process before extracting lead-wire from a plated hole. (Extraction without complete solder removal can cause the foil and plating to peel.)

6.2.3 Remove PC assembly components carefully to avoid lifting and/or tearing of copper lines.

6.2.4 Always replace faulty components with the same part. See recommended spare parts list below.

6.2.5 Clean PC assembly rework with denatured alcohol or a commercially available defluxing solvent.

6.2.6 Inspect rework carefully to insure that work is cleared of "solder splashes" or inadvertent "solder bridges."

Table 4. Recommended Spare Parts

FOR ANALOG PC ASSEMBLY 6694		FOR DIGITAL PC ASSEMBLY 6698	
Designation	Alnor Part No.	Designation	Alnor Part No.
C2	4885A	IC1	437GG
Q1, Q3	1243J	IC2	6948C
Q4	1243AC	IC3	437HH
D1,D2,D3, D4	436R	IC4	476G (was 437JJ)
IC1	476AE (was 437RR)	IC5	476R (was 437KK)
IC2, IC4	6751E	IC6	476F (was 437LL)
IC3	6751R (was 437QQ)	IC7	476H (was 437MM)
R23	6777S	IC8	476AM (was 437NN)
R22	6777T	IC9	476B (was 437PP)
R10	6777U	DS1	6551
S1	6692	L1	6552
IC5	6751D	C3	4876AF
		C1	4876AN
		R1, R2	6777T

FOR MERCURY CELL		NI CAD BATTERY	
Designation	Alnor Part No.	Designation	Alnor Part No.
B3	6635	B1, B2	6671

6.3 Mechanical disassembly

Before troubleshooting or calibrating, disassemble the instrument in the following sequence.

6.3.1 Remove screws at the four corners of case bottom (A, B, C, D).

6.3.2 Desolder and disconnect wires from +14.4 V, GND, TC+, TC-, and CH+. Insulate ends of red and black wires to prevent contact between power connections and vulnerable points on PC boards.

6.3.3 Remove screws from points E and F.

6.3.4 Remove analog and digital PC assemblies from the case.

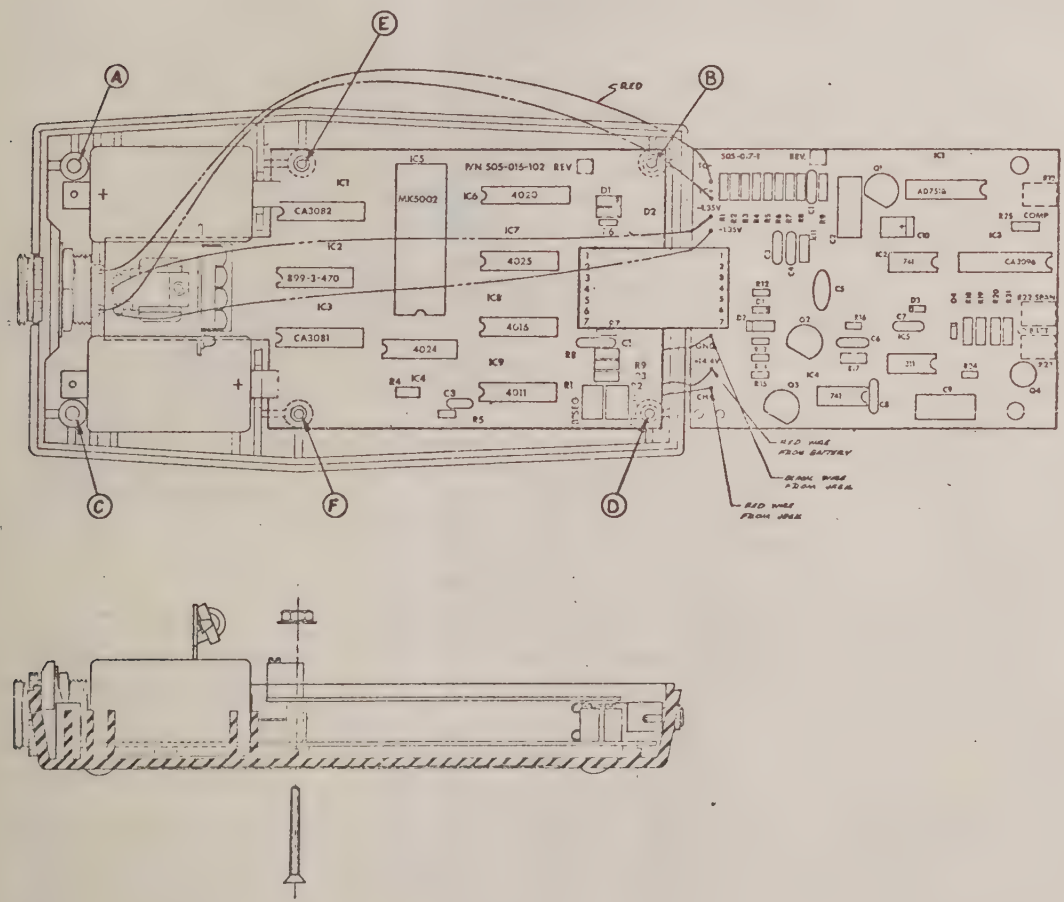


Figure 9.
Instrument Disassembly

6.4 Troubleshooting

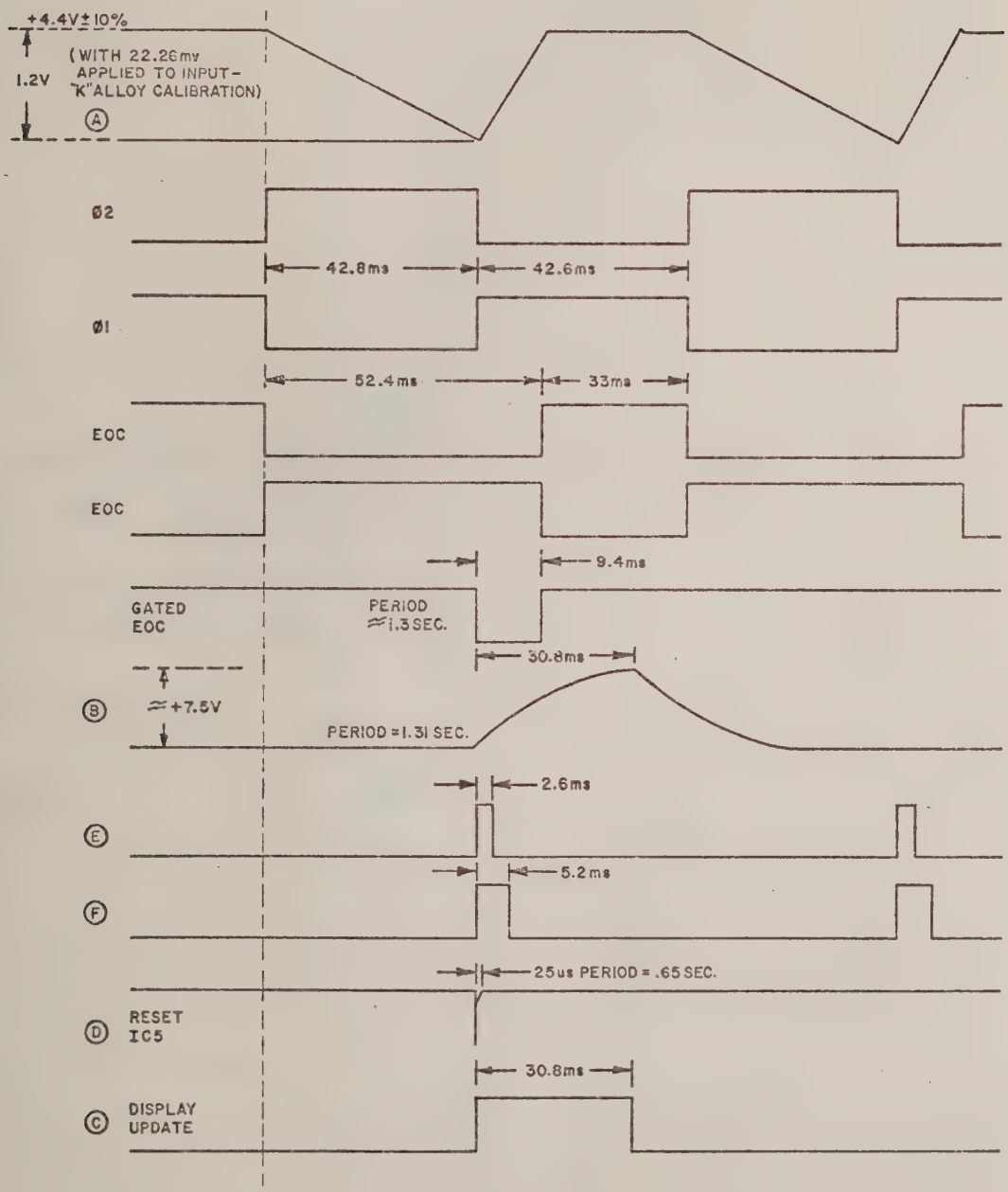
The table below will enable you to isolate troubles to replaceable parts and PC assemblies. Faulty PC assemblies should be returned to Alnor for repair.

Table 5.
Troubleshooting Guide for Digicon®

SYMPTOM	POSSIBLE CAUSES
A. Display "frozen" (no update).	1. If EOC is present and $\overline{EOC}$ is not, collector of Q3 may be open. 2. If EOC is present, problem may be with PC assembly interconnections. 3. If display update pulse is present, with EOC, and Gated EOC is not present, IC9 is faulty. 4. If Gated EOC is present, IC5 (on 6698) may be faulty. 5. If either Φ1 or Φ2 is missing, IC1 (on 6694) may be defective; or IC8 may be defective. 6. Q1 may be open. 7. Q3 may be open. 8. Hg cell may be dead. 9. Cell holder contact may be defective or contaminated. 10. S1B may be open.
B. High number displayed (1000+) with no change as applied mV changes.	1. IC3 (on 6694) may be defective. 2. D2 may be shorted. 3. IC1 (on 6694) may be defective.
C. Single digit lit, or blank display.	1. If clock (pin 3, IC9) is not running, IC8 or IC9 may be defective. 2. R1 or R2 may be open. 3. If clock is running, output (pin 13, IC6) may have failed. 4. If scan pulses are present, IC5 is defective.
D. Adjusting B and/or T SEG pots has no effect.	1. IC8 may be defective. 2. R1 or R2 may be shorted.
E. Display jitters.	1. IC8 may be defective. 2. IC6 may have failed,
F. No Φ1.	1. IC8 may be defective.
G. One or more segments missing.	1. IC1 (on 6698) may be defective. 2. IC2 (on 6698) may be burned out in one or more resistors. 3. DS1 may be defective.
H. Low battery lamp does not light.	1. L1 may be defective. 2. Q2 may be defective.

7.0 Digicon® waveform summary

Waveforms shown are for a unit calibrated for K alloy, °F.
Next page shows reference points.



TYPICAL WAVE FORMS
DIGICON CALIBRATED FOR "K" ALLOY
ms = MILLISECONDS

Figure 10.
Waveform Summary

CONTENTS

Three 6698 Linearizer Settings vs. Clock Frequencies tables

Table 1, for H & E Alloys

Table 2, for J Alloys

Table 3, for K Alloys

Instrument Schematic

6698 Digital PC Assembly Test Points

6694 Analog PC Assembly Test Points

Bill of Materials, on four drawings

6698

6693 (2 sheets)

6694

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